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STRESS ANALYSIS OF 155MM TOWED HOWITZER XM198, SERIAL NUMBERS 3--ETC(U)
JAN 73 C M ROBINDER, D E HEBDON
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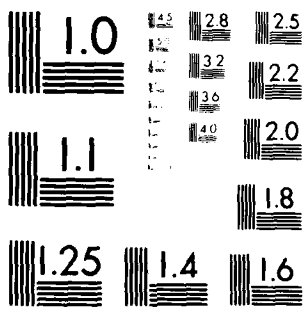

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STRESS ANALYSIS OF 155mm TOWED HOWITZER XM198, SERIAL NUMBERS 3 THROUGH 10 - CRADLE

Technical Note

By

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January 1973

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ABSTRACT

A stress analysis of the cradle of the 155mm Howitzer, XM198, has been performed by the Research Directorate, Weapons Laboratory (WECOM). The calculations of the stresses for the weapons with serial numbers 3 through 10, are given in the Technical Note.

Standard stress analysis techniques were used throughout the study.

The cradle can withstand the loads that are anticipated in the firing of the weapon.

<u>CONTENTS</u>

MAIN STRUCTURF

The cradle is a "U-shaped" aluminum weldment with box section structural members. The material is aluminum alloy 5083, temper 0, with a yield strength of 21,000 pounds per square inch.

The entire cradle is examined with particular emphasis placed on the following areas:

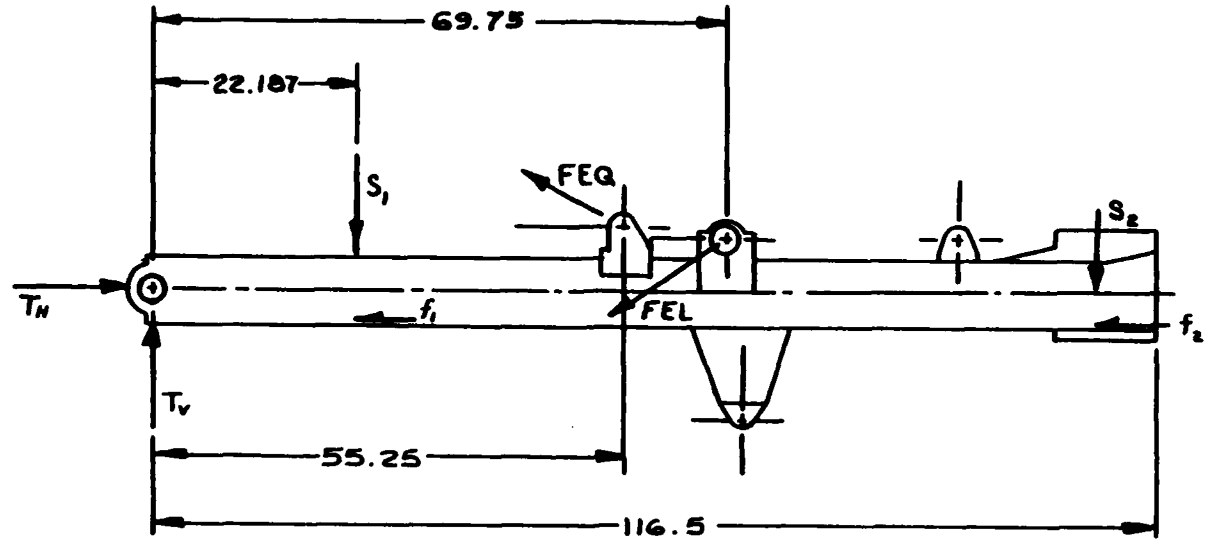
1. Hole for mounting recoil rail guide.
2. Travel lock strut.
3. Beam section, 43 thru 51 inches from the trunnion.

The values for the bending moments on the cradle are from the dynamic force analysis by Jerry Frantz and Michael Nerdahl.

The value of the bending moment at a particular section varies with each angle of elevation. Because the bending stresses in a beam are proportional to the bending moment, the maximum absolute value of the bending moment at each section is used. The maximum absolute values of the bending moments at the points of force application are as follows:

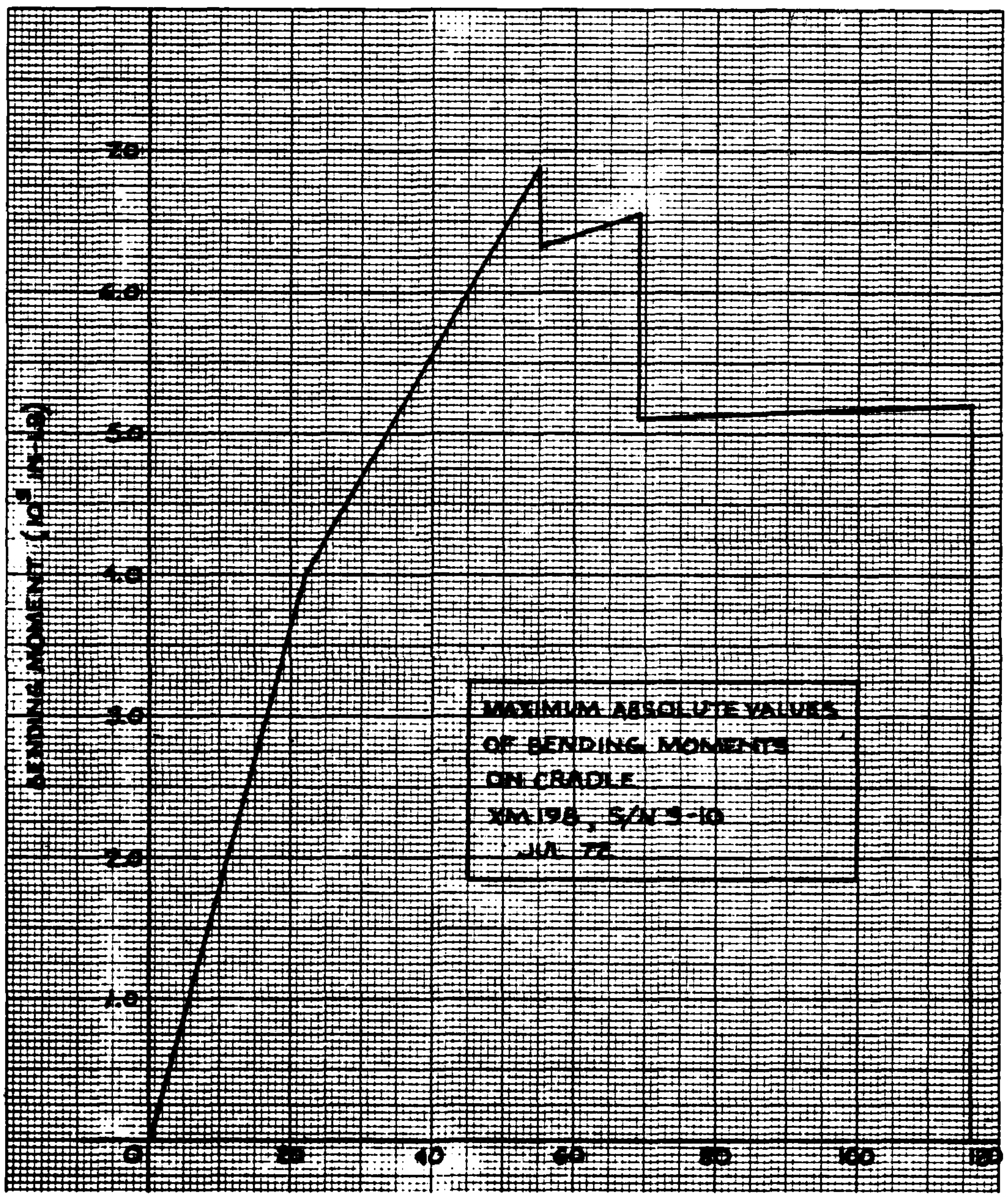
Distance from Trunnions (Inches)	Moment (Inch-Pounds)
22.187	400,264
55.25^-	690,450
55.25^+	633,600
69.75^-	652,037
69.75^+	511,529
113.5	520,666

A free body diagram of the cradle is given on the following page, Figure 1. In Figure 2, the bending moment is plotted as a function of the distance along the cradle. Distances are measured from the trunnion centerline. The distance also identifies the section number.



CRADLE
FREE BODY DIAGRAM

FIGURE 1.



DISTANCE FROM TRUNNION
(IN)

Figure 2

All dimensions are inches, moments of inertia are inches to the fourth power, section moduli are inches cubed, and stresses are pounds per square inch.

<u>Calculation of Section Properties</u>

x = distance from the trunnions to the section

x	Inertia and Section Moduli
0 - 6	$I = \frac{2(3)(8)^3}{12} = 256.$
	$Z = \frac{I}{4} = 64.$
6 - 13.5	$I = \frac{5.88(8)^3}{12} = 250.$
	$Z = \frac{I}{4} = 62.72$
13.5 - 15.6	Same as sections at 0 - 6
25.5 - 42	$I = 2[\frac{8(8)^3 - 7(7)^3}{12}] = 282.5$
	$Z = \frac{I}{4} = 70.6$
58.12 - 59.94	$I = \frac{2(3.3)(8)^3}{12} = 281.6$
	$Z = \frac{I}{4} = 70.4$
75.25 - 95.25	Same as 25.5 to 42

Section 22.187

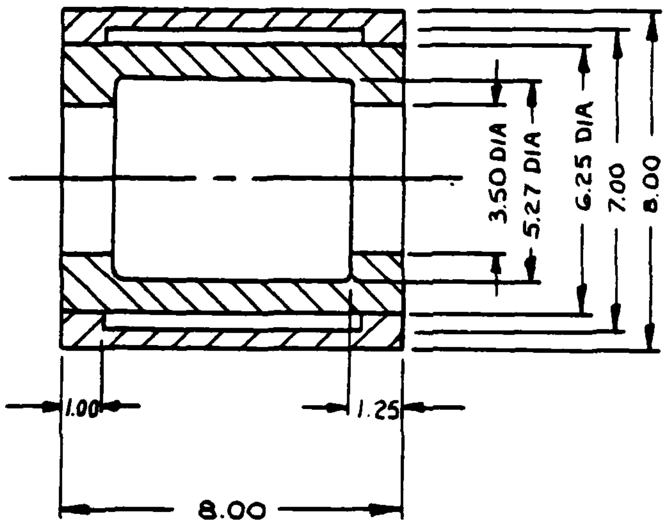


Figure 3

$$I = \frac{2}{12}\left[8(8)^3 - 5.5(5.27)^3 - 2.5(3.5)^3 - 6(7)^3 + 6(6.25)^3\right]$$

$$I = 431.8$$

$$Z_1 = Z_2 = \frac{I}{4}$$

$$Z = 107.9$$

For sections 15.6 thru 25.5, the moment of inertia and the section moduli are equal to or greater than those at section 22.187.

Section 43 thru 49

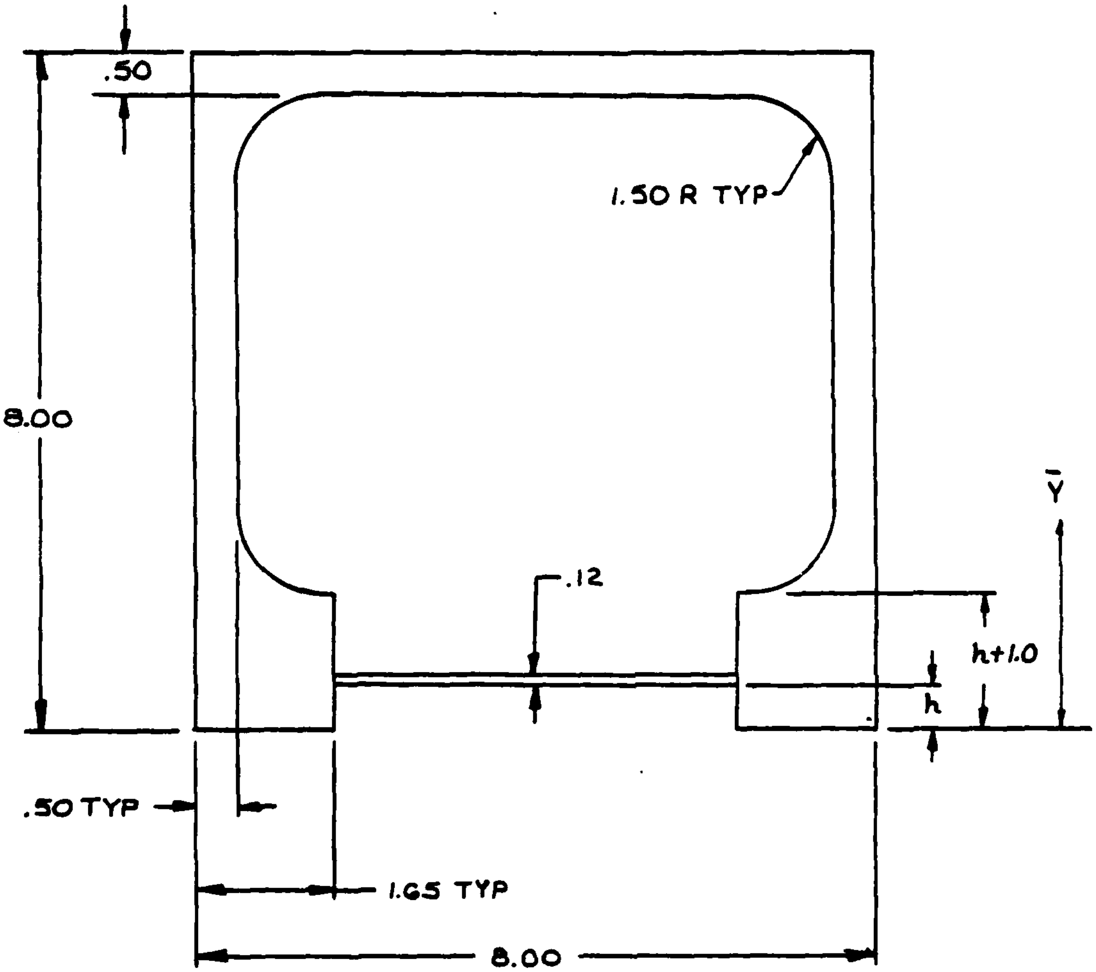


Figure 4

Height of the .12 inch thick plate varies along the cradle.

The above section is for one side of the cradle only. Moments of inertia and section moduli are for only one side of the cradle.

The radiused areas are approximated using squares of equal area and coinciding centers of gravity.

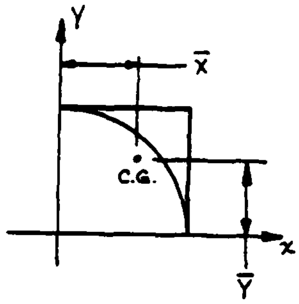


Figure 5

$$A = \frac{3 \times 3 - \pi(1.5)^2}{4}$$

$$A = .48285 \text{ IN}^2$$

$$M = \int_0^{1.5} x(1.5 - y)dx$$

$$M = .5626 \text{ IN}^3$$

$$\overline{X} = \overline{Y} = \frac{M}{A}$$

$$\overline{X} = 1.1649 \text{ IN}$$

Section	h	A	I	Z_1	Z_2	$\overline{Y}$
43	0.63	17.74	150.97	37.54	37.94	4.02
44	1.10	18.82	152.55	38.76	37.53	3.94
45	1.58	19.93	152.75	39.33	37.11	3.88
46	2.00	20.90	152.31	39.42	36.83	3.86
47	2.48	22.00	151.61	39.17	36.72	3.87
48	2.95	23.08	151.20	38.86	36.79	3.89
49	3.40	24.12	151.44	38.52	37.22	3.93

Section 49 thru 51

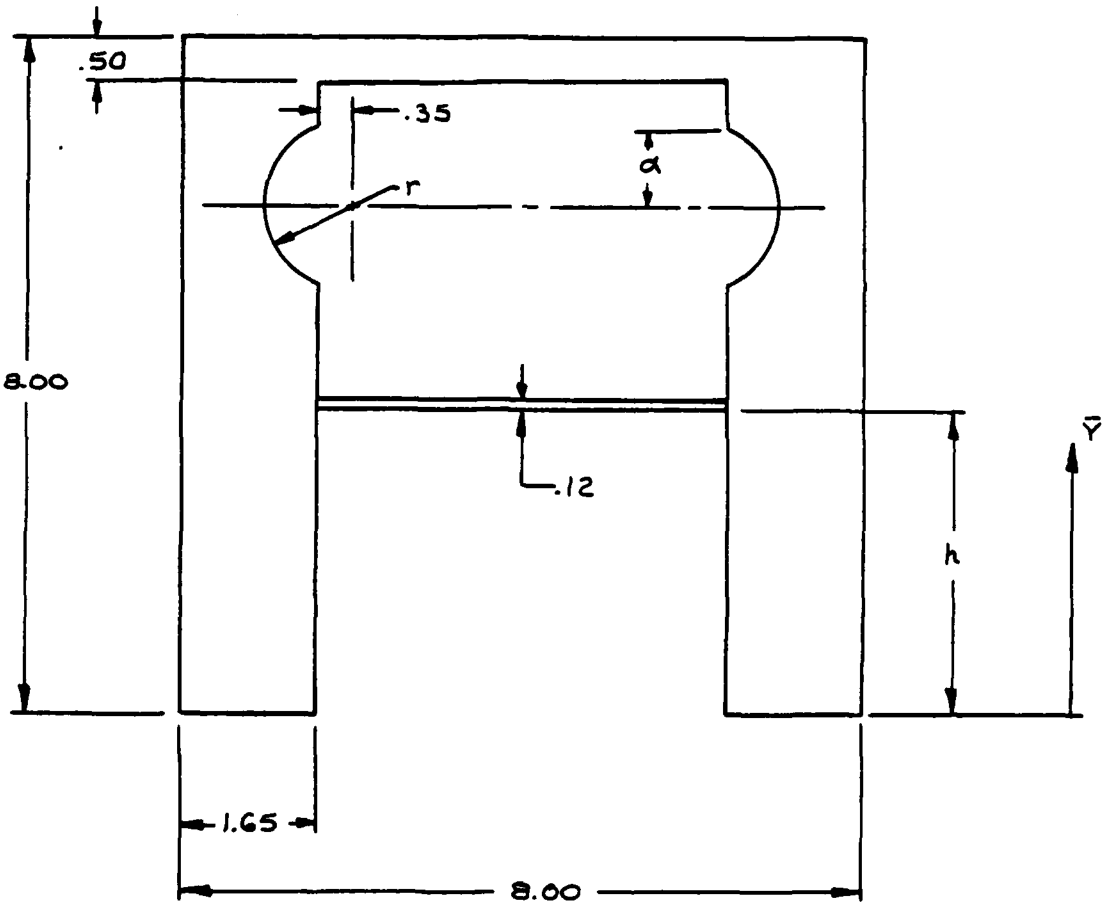


Figure 6

$r = 1.5 \text{ SIN } [\text{COS}^{-1}(\frac{u}{1.5})]$ $\quad\quad u = \chi - 49.0$

$\alpha = r \text{ SIN } [\text{COS}^{-1}(\frac{.35}{r})]$ $\quad\quad u \leq 1.5$

Height of the .12 inch thick plate varies along the cradle.

The above section is for one side of the cradle only. Moments of inertia and section moduli are for only one side of the cradle.

The radiused areas are approximated using squares of equal area and coinciding centers of gravity.

$$A = \int_0^{\alpha} (r-z)dy \qquad \text{where } z^2 + y^2 = r^2$$

$$z = \sqrt{r^2 - y^2}$$

$$A = \int_0^{\alpha} r\ dy - \int_0^{\alpha} \sqrt{r^2 - y^2\ dy}$$

$$A = [ry - \frac{y}{2}\sqrt{r^2 - y^2} + \frac{r^2}{2}\ \mathrm{SIN}^{-1}(\frac{y}{r}\ ]_0^{\alpha}$$

$$A = r\alpha - \frac{\alpha}{2}\sqrt{r^2 - \alpha^2} - \frac{r^2}{2}\ \mathrm{SIN}^{-1}(\frac{\alpha}{r})$$

$$M = \int_0^{\alpha} y(r-z)dy$$

$$M = \int_0^{\alpha} rydy - \int_0^{\alpha} y\sqrt{r^2 - y^2 dy}$$

$$M = [\frac{ry^2}{2} + \frac{1}{3}(r^2 - y^2)^{3/2}]_0^{\alpha}$$

$$M = \frac{r\alpha^2}{2} + \frac{1}{3}(r^2 - \alpha^2)^{3/2} - \frac{1}{3} r^3$$

$$\bar{y} = \frac{M}{A}$$

Section	h	A	I	Z_1	Z_2
49.5	3.62	25.19	155.00	38.69	38.81
50	3.85	27.41	165.01	39.48	43.19
51	4.30	29.40	171.20	39.75	46,35

Sections at x 52 to x = 58.12

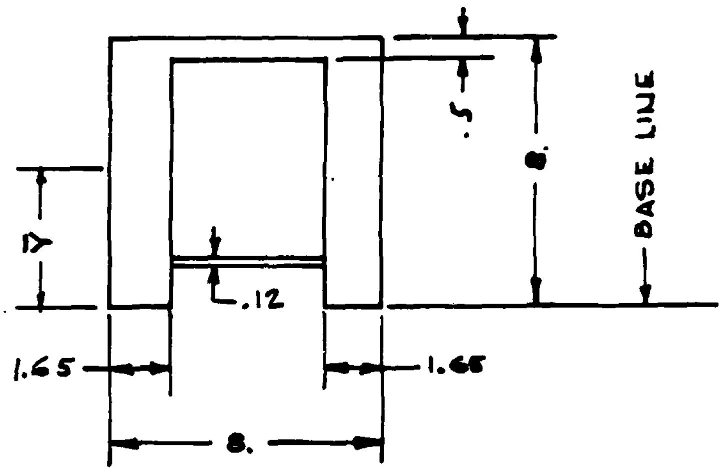


Figure 7

Sections at x = 59.94 to x = 64.25

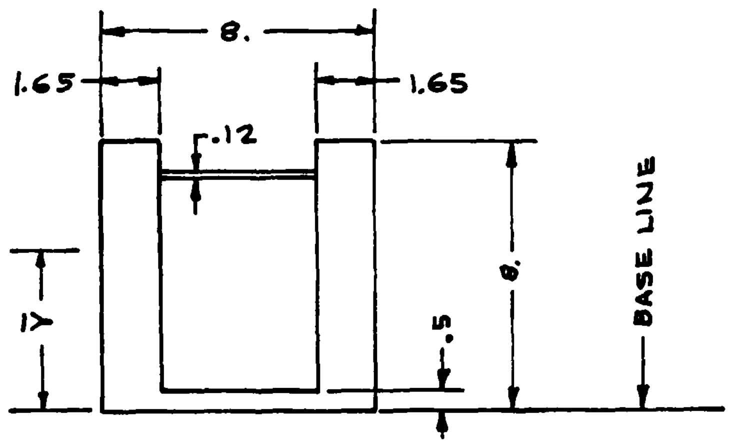


Figure 8

Height of the .12 inch thick plate varies along the cradle.

The above sections (Figures 7 & 8) are for one side of the cradle only. Moments of inertia and section moduli, calculated by the computer, are for only one side of the cradle.

Section	h	$\bar{Y}$	I	Z_1	Z_2
52	4.80	4.316	171.3	39.70	46.51
53	5.25	4.325	171.7	39.70	46.71
54	5.70	4.333	172.3	39.75	46.98
55	6.15	4.342	173.1	39.86	47.31
56	6.60	4.351	174.1	40.02	47.71
57	7.10	4.360	175.5	40.25	48.22
61	1.10	3.644	174.9	48.01	40.15
62	1.70	3.655	173.4	47.44	39.91
63	2.35	3.668	172.2	46.95	39.75
64	3.10	3.682	171.4	46.55	39.69

The configuration of the travel lock strut greatly increases the section moduli of cradle section 64.25 thru 75.25. With the exception of sections 66.375 and 67.375, the section moduli are not computed in this area. The sections 66.375 and 67.375 are examined because of the stress concentration at the threaded holes.

Section 66.375

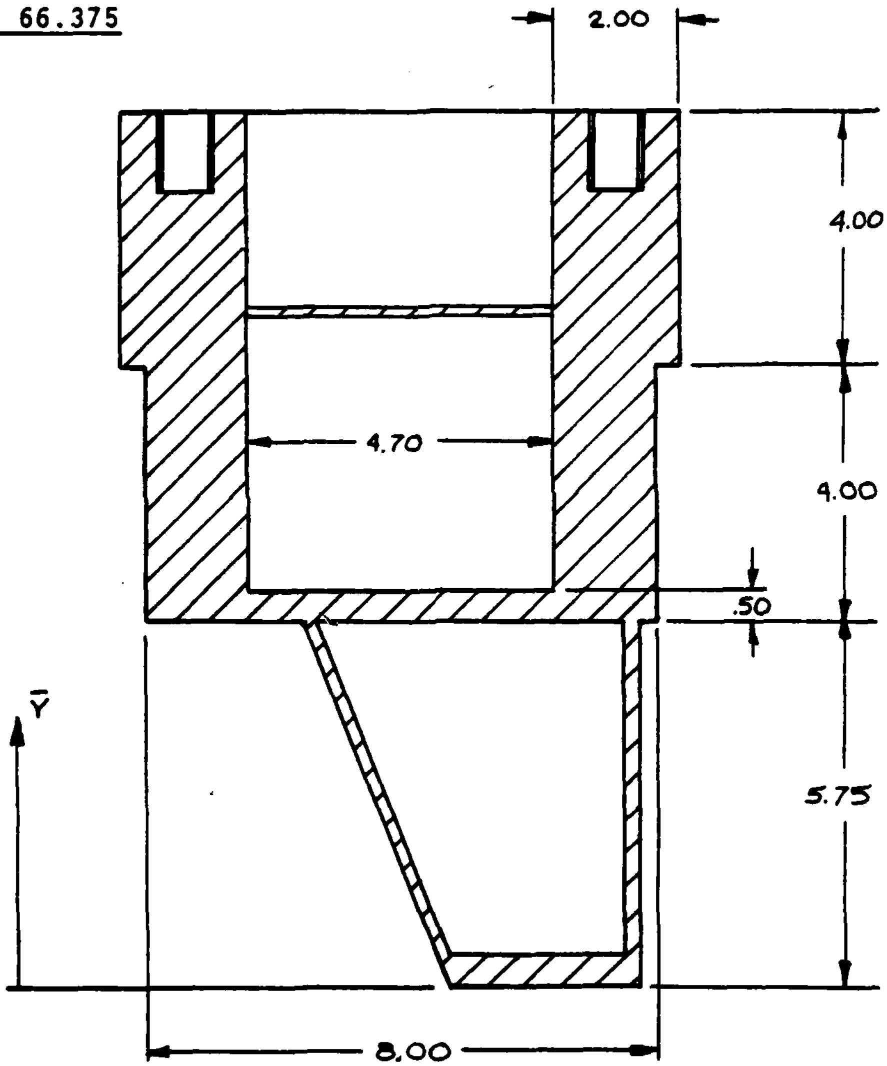


Figure 9

$A = 34.46$, $I = 376.03$, $Z_1 = 43.57$, $Z_2 = 73.44$

$\bar{y} = 8.63$

Section 67.375

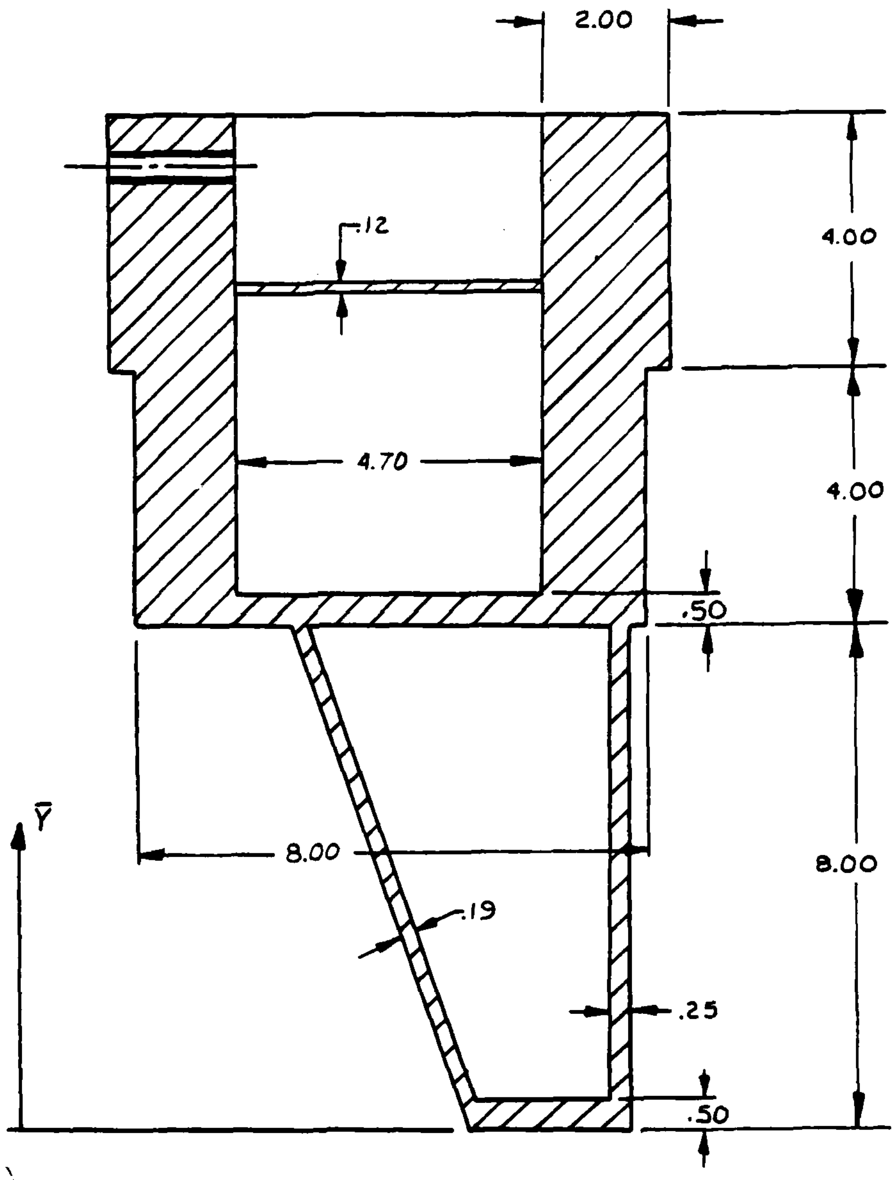


Figure 10

$A = 36.96$, $I = 530.34$, $Z_1 = 48.90$, $Z_2 = 102.90$

$\bar{y} = 10.85$

Section Moduli

Z_1 is the section modulus on the lower side of the cradle

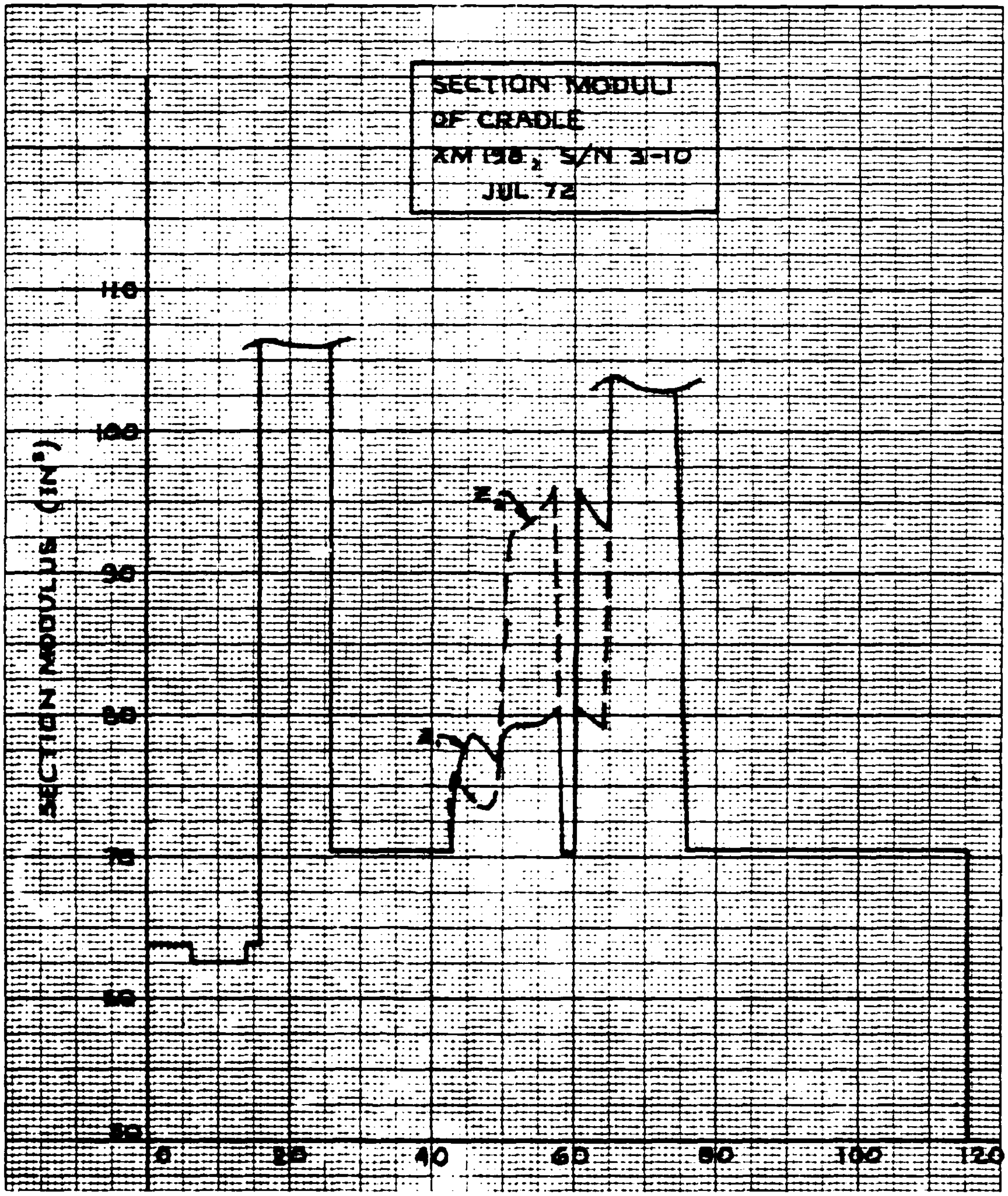
Z_2 is the section modulus on the upper side of the cradle

X is the distance from the trunnion center line

X	Z_1	Z_2	X	Z_1	Z_2
0.0- 6.0	64.0	64.0	52.	79.4	93.0
6.0-13.5	62.72	62.72	53.	79.4	93.4
13.5-15.6	64.0	64.0	54.	79.5	94.0
15.6-25.4	107.9	107.9	55.	79.7	94.6
25.4-42.0	70.6	70.6	56.	80.0	95.4
43.	75.1	75.9	57.	80.5	96.4
44.	77.5	75.1	58.12-59.94	70.4	70.4
45.	78.8	74.2	61.	96.0	80.3
46.	78.8	73.6	62.	94.9	79.8
47.	78.3	73.4	63.	93.9	79.5
48.	77.7	73.6	64.	93.1	79.4
49.	77.0	74.4	66.375	87.2	146.9
49.5	77.4	77.6	67.375	97.8	205.8
50.	79.0	86.4	75.25-95.25	70.6	70.6
51.	79.5	92.7			

Section moduli are given for the entire cradle cross section.

See Figure 11.



DISTANCE FROM TRUNNION
(IN)

Figure 11

Stress calculations

Bending stresses in the cradle are calculated according to the flexure formula. The absolute values of the bending stresses in the cradle are plotted against the distance from the trunnion in Figure 12. The peak bending stress is 9202 pounds per square inch and occurs at section 59.95.

The threaded hole at section 66.375 is considered in the calculation of the section properties. At section 67.375, the nominal stress at the hole is 4.40/5.15 times the top fiber stress. Here a stress concentration factor of 3 is applied. The stress values at the two sections are as follows:

S_1 is the lower fiber bending stress
S_2 is the upper fiber bending stress
S^* is the maximum bending stress at the hole

X	M	S_1	S_2	S^*
66.375	667,301	7658	4543	4543
67.375	670,330	6854	3257	8348

High bending stresses occur at sections 15.6, 42.00, 49.00, 55.25, and 59.95. The cradle has, in addition to the bending stresses, a uniform compressive stress on each section which is caused by the axial component of the trunnion reaction. Each of the above sections is examined for the effect of combined stresses.

Section 15.6

The maximum moment at section 15.6 occurs at .1425 seconds when firing at 0 degree elevation.

$$P = T_h = 124{,}345 \text{ lb}$$

$$S_c = \frac{P}{A}$$

$$A = 2(8 \times 3) = 48 \text{ in}^2$$

$$S_c = \frac{124{,}345}{48} = 2590 \text{ psi}$$

$S_b = M/Z_2 = 4397$ psi

$\sigma = S_c + S_b$

$\sigma = 2590 + 4397$

$\sigma = 6987$ psi

<u>Section 42.00, 49.00, and 55.25</u>

The maximum moment at sections 42.00, 49.00, and 55.25 occurs at .1555 seconds when firing at 50 degree elevation.

$P = T_h = 123,635$ lb

Section 42.00

$$S_c = \frac{P}{A}$$

$$A = 2\,(8^2 - 7^2)$$

$$A = 30 \text{ in}^2$$

$$S_c = \frac{123,635}{30}$$

$$S_c = 4121 \text{ psi}$$

$$S_b = \frac{M}{Z_2} = 8132 \text{ psi}$$

$$\sigma = S_c + S_b$$

$$\sigma = 4121 + 8132$$

$$\sigma = 12253 \text{ psi}$$

Section 49.00

$$S_c = \frac{P}{A}$$

$$A = 2(24.12)$$

$$A = 48.24 \text{ in}^2$$

$$S_c = \frac{123{,}635}{48.24}$$

$$S_c = 2562 \text{ psi}$$

$$S_b = \frac{M}{Z_2} = 8539 \text{ psi}$$

$$\sigma = S_c + S_b$$

$$\sigma = 2562 + 8539$$

$$\sigma = 11{,}101 \text{ psi}$$

Section 55.25

$$S_c = \frac{P}{A}$$

$$A = 2(29.31)$$

$$A = 58.62 \text{ in}^2$$

$$S_c = \frac{123{,}635}{58.62}$$

$$S_c = 2109 \text{ psi}$$

$$S_b = \frac{M}{Z_2} = 8633 \text{ psi}$$

$$\sigma = S_c + S_b$$

$$\sigma = 2109 + 8633$$

$$\sigma = 10{,}742 \text{ psi}$$

Section 59.95

The maximum moment at section 59.95 occurs at .0465 seconds when firing at 35 degree elevation with short recoil.

$$P = T_h - F_{eq} \text{ COS } \lambda$$

$$P = 70{,}036 - 28{,}732 \text{ COS } (11.37)$$

$$P = 41{,}868 \text{ lb}$$

$$S_c = \frac{P}{A}$$

$$A = 2(26.4)$$

$$A = 52.8 \text{ in}^2$$

$$S_c = \frac{41{,}868}{52.8}$$

$$S_c = 792 \text{ psi}$$

$$S_b = \frac{M}{Z_2} = 9202 \text{ psi}$$

$$\sigma = S_b + S_c$$

$$\sigma = 9202 + 792$$

$$\sigma = 9994 \text{ psi}$$

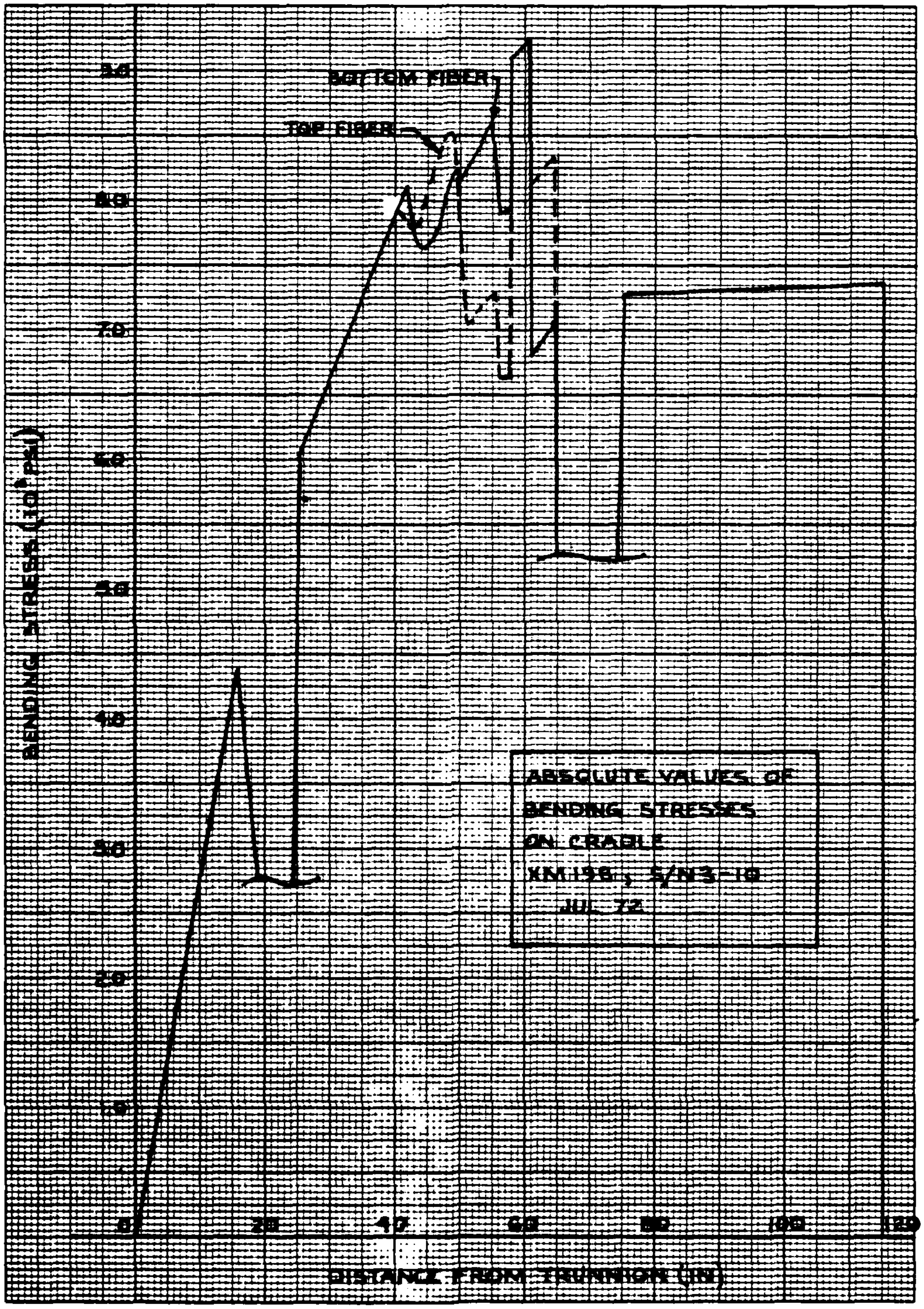

BOTTOM FIBER
TOP FIBER
BENDING STRESS (10^3 PSI)
DISTANCE FROM TRUNNION (IN)
ABSOLUTE VALUES OF
BENDING STRESSES
ON CRADLE
XM198, S/N3-10
JUL 72
0
20
40
60
80
100
120
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0

Figure 12

At .005196 seconds, the cradle arms are subjected to the maximum torque produced by the rifling torque reaction on the guide assemblies. The resulting torsional shear stress is maximum on the outside of the center fiber of each cradle arm. At this point, the bending stresses are zero. The octahedral shear stress theory is used to combine the torsional shear stress with the uniform compressive stress produced by the axial component of the trunnion reaction.

The sections 5.00, 10.00, and 40.00 are assumed to be representative of the stress conditions in the entire cradle arm. Beyond section 55.25, the uniform compressive stress is reduced by the elevating mechanism and the equilibrator reactions.

Axial Force F_h max. = 32,750 lb

Rifling torque

$$T_r = \frac{.6\ \pi\ R_b F_g}{N_r}$$

N_r = 20 cal/turn, twist of rifling

F_g = Gas force = 1,635,738 lb

R_b = bore radius = 3.05 in.

T_r = 470,202 in-lb

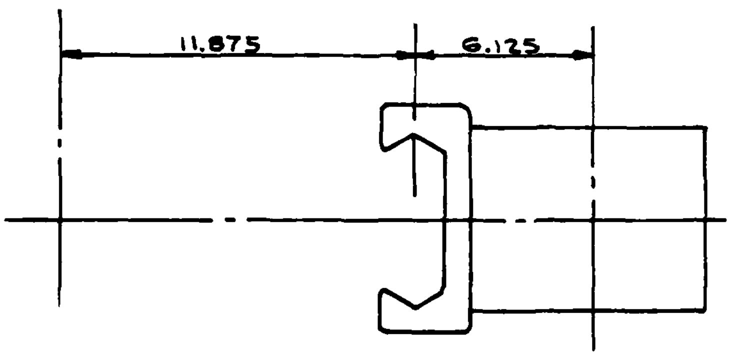


Figure 13

The rifling torque is reacted by a couple at the guides.

Force at guides = $P = \frac{T_r}{23.75}$ = 19,798 lb

Torque on arm of cradle

= 6.125P = 121,262 in-lb

Section 5.00

$$\tau = \frac{T}{\alpha b h^2}$$

$$\frac{b}{h} = \frac{8}{3} = 2.667 \rightarrow \alpha = .26$$

$$\tau = \frac{121,262}{.26(8)(3)^2}$$

$$\tau = 6478 \text{ psi}$$

$$\sigma = \frac{P}{A} = \frac{32750}{8x3}$$

$$= 1365 \text{ psi}$$

Stresses are combined by the Maximum Distortion Energy Theory. (Effective Stress Theory)

σ_g = maximum stress

$$\sigma_g = \sqrt{\sigma^2+3\tau^2}$$

$$\sigma_g = \sqrt{1365^2+3(6478)^2}$$

$$\sigma_g = 11,302 \text{ psi}$$

Section 10.00

$$\tau = \frac{T}{\alpha b h^2}$$

$$\frac{b}{h} = \frac{8.00}{2.88} = 2.78 \rightarrow \alpha = .267$$

$$\tau = \frac{121,262}{.267(8)(2.88)}$$

$$\tau = 6850 \text{ psi}$$

$$\sigma = \frac{P}{A} = \frac{32,750}{8x2.88}$$

$$\sigma = 1421 \text{ psi}$$

$$\sigma_g = \sqrt{1421^2 + 3(6850)^2}$$

$$\sigma_g = 11{,}949 \text{ psi}$$

Section 40.00

$$\tau = \frac{T}{2bht}$$

$$\tau = \frac{121{,}262}{2(8.00)(8.00)(.5)}$$

$$\tau = 1895 \text{ psi}$$

$$\sigma = \frac{P}{A} = \frac{32{,}750}{8^2 - 7^2}$$

$$\sigma = 2183 \text{ psi}$$

$$\sigma_g = \sqrt{2183^2 + 3(1{,}895)^2}$$

$$\sigma_g = 3941 \text{ psi}$$

TRAVEL LOCK STRUT

The travel lock strut is an aluminum weldment attached to the cradle. It has a box shaped cross section. The purpose of the travel lock strut is to anchor the cradle to the bottom carriage during transport.

The material is aluminum alloy 5083, temper 0, which has a yield strength of 21,000 pounds per square inch.

During transport, the travel lock strut must sustain a load of 9 g's.

$$F = 10{,}470 \times 9$$

$$F = 94{,}230 \text{ lb.}$$

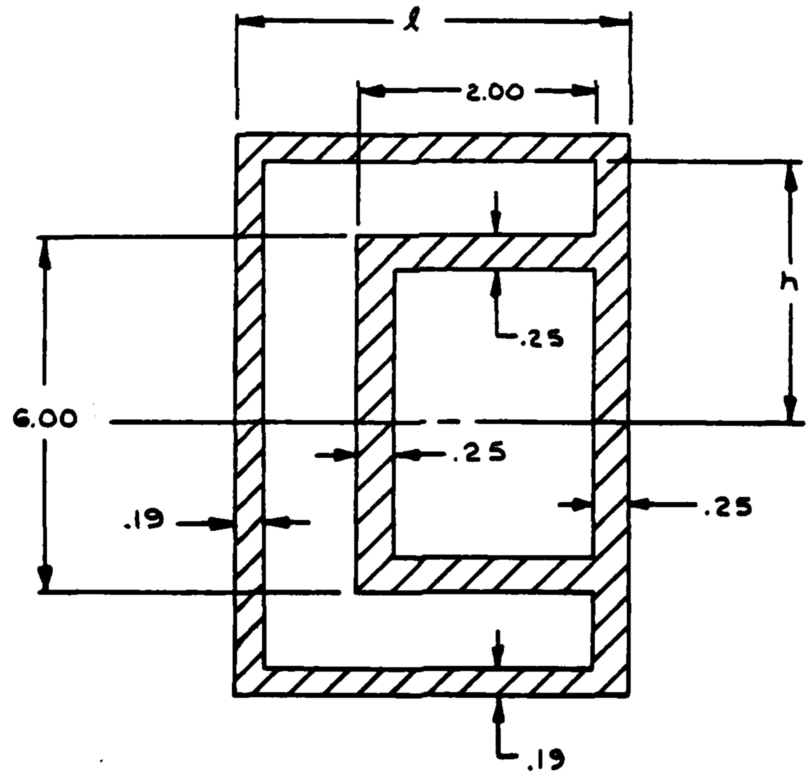


Figure 14

Distance from Cradle (inches)	h (inches)	ℓ (inches)
0.0	5.75	4.25
1.0	5.44	4.04
2.0	5.13	3.83
3.0	4.81	3.63
4.0	4.50	3.42
5.0	4.19	3.21
6.0	3.88	3.00
7.0	3.56	2.79
8.0	3.25	2.58
9.0	2.94	2.38

The travel lock strut is treated as a cantilever beam with the cradle end fixed. The load is applied at 52 degrees to the cradle.

All dimensions are inches, moments of inertia are inches to the fourth power, section moduli are inches cubed, and stresses are pounds per square inch.

$$M = F \cos 52^\circ (10.5 - X) \qquad X = \text{Distance from cradle}$$

$$I = \frac{2}{12} [\ell(2h+.375)^3 - (\ell-.44)(2h)^3+2(6)^3 - 1.75(5.5)^3]$$

$$Z = \frac{I}{h+.19}$$

$$S_b = \pm \frac{M}{Z}$$

$$S_c = -\frac{F \sin 52^\circ}{A}$$

$$A = 2 [(2h)(.44) + \ell (.375) + 2(.5) + (5.5)(.25)]$$

At Center Fiber

$$S_s = \frac{VQ}{Ib}$$

$V = F \cos 52^{o}$

I = Moment of Inertia

b = Cross Section Thickness

= 1.375 in.

$Q = 2\Sigma YA$

$= .44h^2 + .19\ell\,(2h+.19) + 2(.25)(5.75)$

$+.25(2.75)^2$

At Outer Fiber

$\sigma_1 = S_b + S_c$

$\sigma_2 = -S_b + S_c$

At Center Fiber

$\sigma_g = \sqrt{S_c{}^2+3S_s{}^2}$ (Maximum Distortion Energy or Effective Stress Theory)

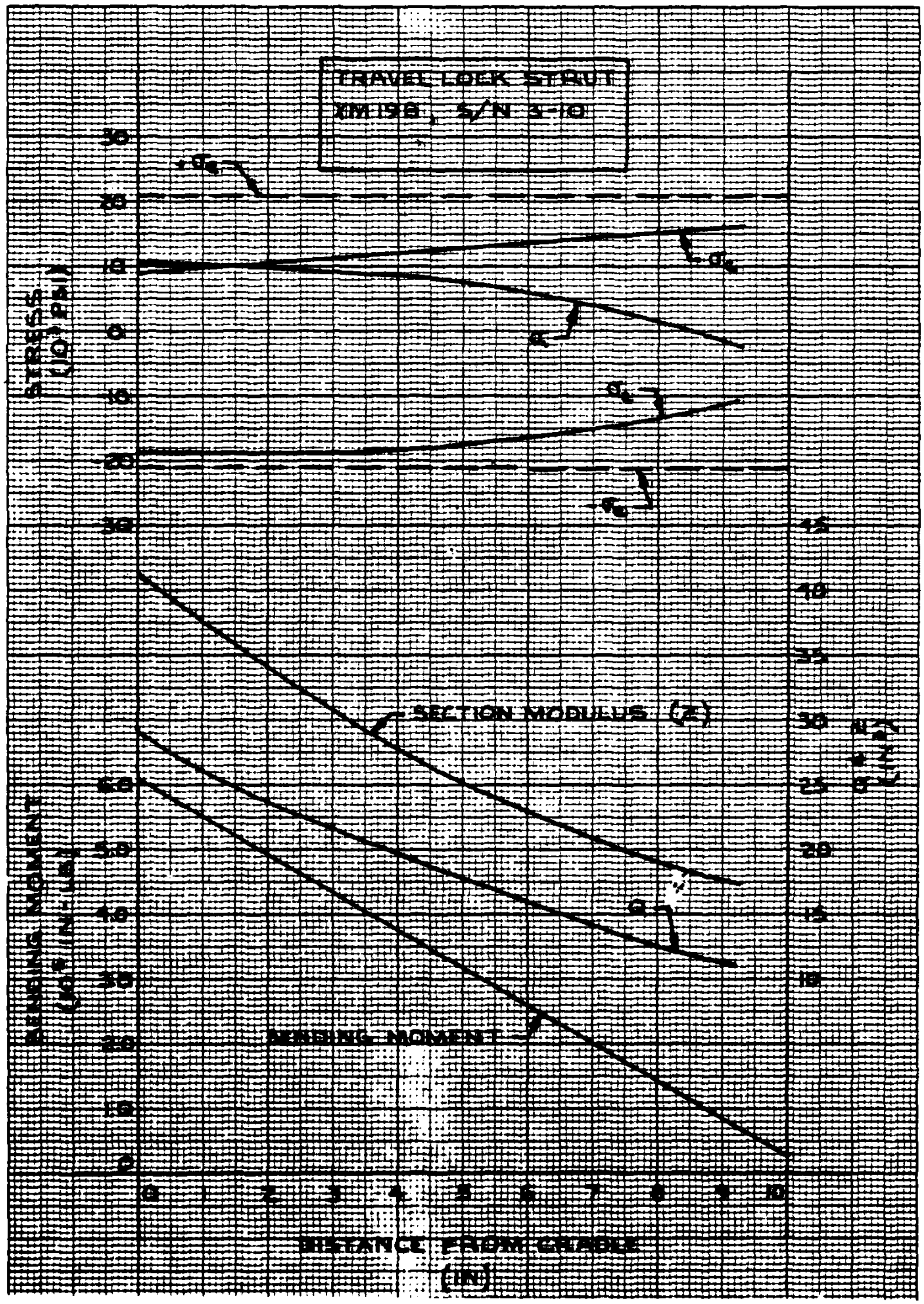
Values of the section properties and stresses at one inch increments from the cradle are given in Table I. These values are plotted in Figure 15.

The peak stresses are -19,002 psi at the outer fiber and 16,360 psi at the center fiber.

TABLE I

TRAVEL LOCK STRUT

X	M	I	Z	A	Q	Sb	Sc	Ss	σ_1	σ_2	σ_g
0	609144	243.9	41.1	18.07	28.75	14,837	-4,110	4,975	10,727	-18,947	9,546
1	551131	210.7	37.4	17.36	26.28	14,725	-4,276	5,263	10,449	-19,002	10,069
2	493117	181.1	34.0	16.66	23.95	14,488	-4,457	5,581	10,032	-18,945	10,644
3	435103	154.2	30.8	15.95	21.71	13,716	-4,656	5,939	9,060	-18,372	11,292
4	377090	131.1	27.9	15.24	19.65	13,493	-4,871	6,324	8,623	-18,364	11,988
5	319076	110.8	25.3	14.54	17.72	12,612	-5,106	6,746	7,505	-17,718	12,750
6	261062	93.3	22.9	13.84	15.92	11,391	-5,366	7,202	6,025	-16,757	13,578
7	203048	77.9	20.8	13.12	14.22	9,776	-5,660	7,702	4,116	-15,436	14,491
8	145034	65.2	19.0	12.42	12.69	7,646	-5,981	8,207	1,665	-13,627	15,422
9	87021	54.8	17.5	11.72	11.31	4,969	-6,336	8,708	-1,367	-11,305	16,360



TRAVEL LOCK STRUT
XM198, S/N 3-10
STRESS
SECTION MODULUS (Z)
BENDING MOMENT
DISTANCE FROM CRADLE
(IN)

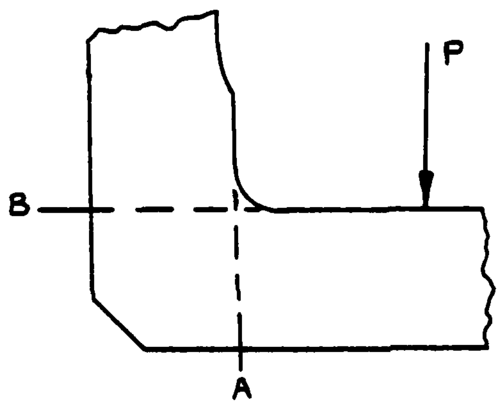
Figure 15

GUIDE ASSEMBLY

The guide assemblies are attached to the cradle 22.187 inches forward of the trunnion centerline. They are used to support the recoiling parts and to transmit the rifling torque to the trunnions.

The guide is made of aluminum alloy 6061, T6. A bronze sleeve is fitted on the inside surface for the recoil rail to slide on.

Guide



Al Alloy 6061, T6

σ_e = 40,000 psi

Figure 16

$$P = \frac{T_r}{d}$$

T_r = Rifling Torque

d = Distance Between Guides

$$T_r = \frac{.6\pi^2 R_b{}^3 P_g}{N_r} \qquad P_g = \frac{F_g}{\pi R_b{}^2}$$

$$T_r = \frac{.6\pi R_b F_g}{N_r}$$

Where R_b = Bore Radius

F_g = Gas Force

N_r = Rifling Twist

P_g = Gas Pressure

$$T_r = \frac{.6\pi(3.05)(1,635,738)}{20}$$

$$T_r = 470,202 \text{ in-lb}$$

$$P = \frac{470,202}{23.75}$$

$P = 19,798$ lb AT .005196 Sec.

Stresses:

Section A

$\sigma = K \frac{M}{Z}$ K = Stress Concentration Factor = 1.5

$$M = 1.093\ (19,798) = 21,639 \text{ in-lb}$$

$$Z = \frac{bh^2}{6}$$

$$= \frac{8.00(.875)^2}{6}$$

$$= 1.0208 \text{ in}^3$$

$$\sigma = 1.5\ \left(\frac{21,639}{1.0208}\right)$$

$$\sigma = 31,796 \text{ psi}$$

$$\tau = \frac{VQ}{Ib}$$

$$V = P$$

$$Q = \frac{b}{2}\left(\frac{h^2}{4} - y^2\right) \; ; \; y = o$$

$$I = \frac{bh^3}{12}$$

$$\tau \max = \frac{V}{2(bh^3/12)}\left(\frac{h^2}{4}\right)$$

$$= \frac{3V}{2bh} = \frac{3V}{2A}$$

$$\tau \max = \frac{3(19,798)}{2(8.00)(.875)}$$

$$\tau \max = 4242 \text{ psi}$$

Section B:

The guide originally was designed so that this section was in bending and in tension. This was found to be overstressed. Therefore, the design was changed to eliminate the clearance between the cradle and the guide. This prevents bending in the vertical portion of the guide.

$$S_t = K\frac{P}{A} \quad ; \quad K = 2.0$$

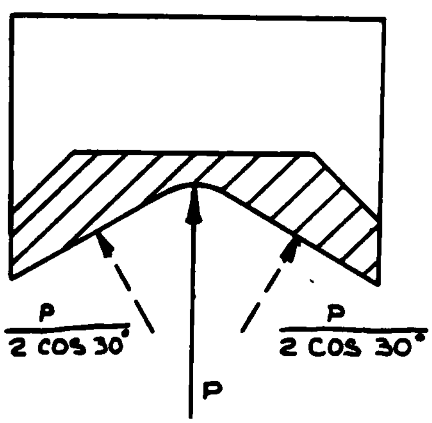
$$A = 8.00\ (.907)$$

$$A = 7.26\ \text{in}^2$$

$$S_t = 2.0\ \left(\frac{19,798}{7.26}\right)$$

$$S_t = 5457\ \text{psi}$$

Sleeve



Bronze, Manganese

Class B Hard

σ_e = 55,000 psi

Figure 17

Lengthwise of sleeve

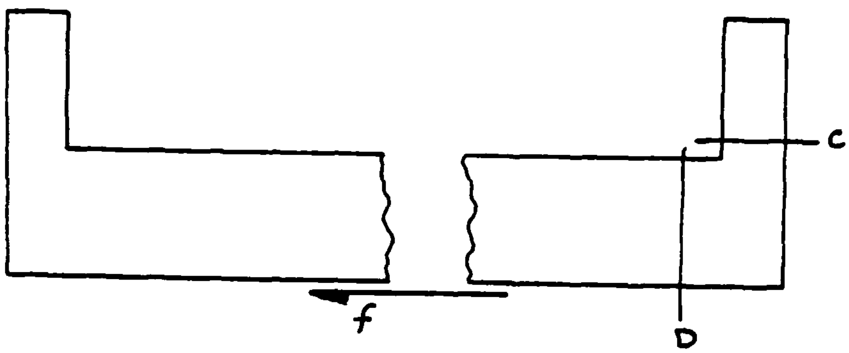


Figure 18

$f = \mu p \qquad \mu = .2$

$f = .2\ (19{,}798)$

$f = 3{,}960$ lb

Shear Stress in End Tabs: (Section C)

$\tau = \frac{f}{A}$

$A = 2.186 \times .375$

$A = .820\ in^2$

$\tau = \frac{3.960}{.820}$

$\tau = 4830$ psi

Tensile Stress in Sleeve Next to Tab (Section D)

$\sigma = K\frac{f}{A}$; $K = 2.0$

$A = 2.186 \times .72 - (.44)^2 - 1.093 \times (1.093 \tan 30')$

$A = .691\ in^2$

$$\sigma = 2.0 \left(\frac{3960}{.691}\right)$$

$$\sigma = 11{,}468 \text{ psi}$$

Bearing Loads:

Case 1. Load is assumed to be evenly distributed normal to the sides.

$$\sigma_{br} = \frac{(P/2)/\cos 30^\circ}{A}$$

$$A = \frac{2.186-.31}{2}\left(\frac{1}{\cos 30^\circ}\right)(8.0)$$

$$A = 8.664 \text{ in}^2$$

$$\sigma_{br} = \frac{19{,}798/(.866)}{2(8.664)}$$

$$\sigma_{br} = 1319 \text{ psi}$$

Case 2. Load is assumed to be evenly distributed normal to project of bearing surface.

$$\sigma_{br} = \frac{P}{A}$$

$$A = 2.186 \times 8.00 = 17.488 \text{ in}^2$$

$$\sigma_{br} = \frac{19{,}798}{17{,}488} = 1132 \text{ psi}$$

CONCLUSIONS

The cradle can withstand the dynamic loads that are anticipated in the firing of the weapon.

REFERENCES

1. Robinder, Catherine M., "Stress Analysis of 155MM Towed Howitzer, XM198, Serial Numbers 1 and 2," SWERR-TR-72-16, Research Directorate, Weapons Laboratory at Rock Island, U. S. Army Weapons Command, Rock Island, Illinois, March 1972.

2. Robinder, Catherine M., "155MM Howitzer XM198-Design Calculations," SWERR-R4-72, Research Directorate, Weapons Laboratory at Rock Island, U. S. Army Weapons Command, Rock Island, Illinois, March 1972.

3. Nerdahl, M. C., and Frantz, J. W., "Mathematical Firings of 155MM Howitzer, XM198," SWERR-TR-72-72, Artillery Weapon Systems Directorate, Weapons Laboratory, WECOM, U. S. Army Weapons Command, Rock Island, Illinois, October 1972.

4. Frantz, J. W., and Nerdahl, M. C., "Mathematical Models for Engineering Analysis and Design of Howitzers, Medium, Towed, 155MM, XM198," RE-TR-70-186, Artillery Systems Laboratory, U. S. Army Weapons Command, Rock Island, Illinois, October 1970.

5. Nerdahl, M. C., and Frantz, J. W., "Mathematical Models for Engineering Analysis and Design of Howitzers, Medium, Towed, 155MM, XM198," Supplement to RE-TR-70-186, Artillery Systems Laboratory, U. S. Army Weapons Command, Rock Island, Illinois, December 1971.

6. Nerdahl, M. C., and Frantz, J. W., "Validation of Mathematical Models for Engineering Analysis and Design of a Towed 155MM Howitzer," RE-TR-71-85, Artillery and Air Defense Weapon Systems Directorate, Weapons Laboratory at Rock Island, U. S. Army Weapons Command, Rock Island, Illinois, December 1971.

REFERENCES

7. Seely, Fred B., and Smith, James O., Advanced Mechanics of Materials, John Wiley & Sons, Inc., New York, 1959.

8. Peterson, R. E., Stress Concentration Design Factors, John Wiley & Sons, Inc., New York, 1953.

9. Timoshenko, Stephen, Strength of Materials, Part II Advanced Theory and Problems, D. Van Nostrand Company, Inc., New York, 1956.

10. Hofgaard, Bjorn L., and Renaud, William L., "Stress Analysis of 155MM Towed Howitzer XM198, Serial Numbers 3 through 10 - Top Carriage," SWERR-R-TN-2-73, Research Directorate, Weapons Laboratory, WECOM, U. S. Army Weapons Command, Rock Island, Illinois, January 1973.

11. Robinder, Catherine M., "Stress Analysis of 155MM Towed Howitzer XM198, Serial Numbers 3 through 10 - Bottom Carriage," N-RR-T-3-13-73, Research Directorate, Weapons Laboratory, Rock Island Arsenal, Rock Island, Illinois, February 1973.

12. Renaud, William L., "Stress Analysis of 155MM Towed Howitzer XM198, Serial Numbers 3 through 10 - Travel Lock & Elevating Screw Housing," N-RR-T-3-14-73, Research Directorate, Weapons Laboratory, Rock Island Arsenal, Rock Island, Illinois, March 1973.

13. Hofgaard, Bjorn L., "Stress Analysis of 155MM Towed Howitzer XM198, Serial Numbers 3 through 10 - Actuator," N-RR-T-3-15-73, Research Directorate, Weapons Laboratory, Rock Island Arsenal, Rock Island, Illinois, March 1973.

14. Robinder, Catherine M., "Section Properties of a Cross Section Composed of Geometric Shapes," N-RR-T-3-16-73, Research Directorate, Weapons Laboratory, Rock Island Arsenal, Rock Island, Illinois, March 1973.

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